records for 1909, 1915, and 1919, and other important matter for Galveston, Tex., have been furnished by the district engineer at Galveston, Tex.

Automatic tide records at Galveston for 1906, 1909, 1916, 1917, and 1919, and important references have been furnished by the Superintendent and other officials of the United States Coast and Geodetic Survey, Washington, D. C.

Reports from lighthouses in the Gulf, and the movement of buoys in storms have been furnished by the Inspector of the Light House District, New Orleans, La.

BIBLIOGRAPHY.

(Including publications not referred to in this paper.)

(1) **Cyclonic Storms in the Bay of Bengal,** by John Eliot, Calcutta, 1900.

(2) **The Tides,** by George H. Darwin, Cambridge, 1898.

(3) **Elementary Meteorology,** by W. M. Davis, Boston, 1894, Chapter X.

(4) **Waves and Ripples,** by J. A. Fleming, London, 1912, Chapters I and II.

(5) **Modern Meteorology,** by Frank Waldo, New York, 1893, Chapter V.

(6) **Waves of the Sea and Other Water Waves,** by Vaughan Cornish, Chicago, Ill., 1910.

(7) **A Practical Manual of Tides and Waves,** by W. H. Wheeler, London, 1906.

(8) Pearson's Magazine, July, 1901, **Kumatology or the Science of Waves,** by Marcus Tindall.

(9) Nautical Magazine, Vol. LXIV, 1895, has three papers by W. H. Wheeler on **The Effect of a Gale Upon the Tides,** on pp. 146, 353, and 1041.

(10) U. S. Engineers Corps Professional Memoirs, vol. 5, 1913, by Col. F. V. Abbot, **Effect of Storms on Tide Levels, etc.,** p. 280.

(11) U. S. Coast and Geodetic Survey Report for 1856, pp. 271-278, has the following articles: **Winds of Albermarle Sound, Discussion of their Effects Upon the Tides,** by F. F. Pourtales. **Winds in the Gulf of Mexico,** by A. D. Bache. And **Winds and Tides in Cat Island Harbor,** by G. W. Dean.

(12) U. S. Coast and Geodetic Survey Report for 1857, pp. 354-358, **Winds on the Western Coast—Discussion,** by A. D. Bache.

(13) Proceedings and Transactions of the Royal Society of Canada, has two articles by W. Bell Dawson as follows: (*a*) Meeting of May, 1909, 3d series, Bul. 3, sec. 3, p. 179, **The Effects of Wind on Currents and Tidal Streams.** (*b*) Meeting of September, 1910, 3d series, vol. 3, p. 8, sec. 3, **Wind Disturbance.**

(14) British Association for the Advancement of Science, 1895, p. 795, by W. H. Wheeler, **The Effects of Wind and Atmospheric Pressure on the Tides.**

(15) British Association for Advancement of Science, 1896, p. 503, by W. H. Wheeler and others, **The Effect of Wind and Atmospheric Pressure on Tides.**

(16) Nature, vol. 56, May to October, 1897, p. 80, by F. L. Ortt, **The Effect of Wind and Atmospheric Pressure on Tides.**

(17) U. S. Coast and Geodetic Survey Report for 1871, appendix 6, p. 93, by Prof. William Ferrel, **Meteorological Effect on Tides.**

(18) **The Wet Lands of Southern Louisiana and their Drainage,** by Charles W. Okey, Senior Drainage Engineer, Bulletin No. 652, U. S. Department of Agriculture, Washington, 1918.

(19) **U. S. Monthly Weather Review,** Washington, 1900, September; 1901, July; 1906, September; 1909, July and September; 1910, October; 1915, August and September; 1916, July and August; 1917, September; 1918, August; and 1919, September.

THE FORECASTING OF SWELLS ON THE COAST OF MOROCCO.

By LOUIS GAIN.

[Abstracted from Revue général des Sciences, July 15, 1919, pp. 408-411.]

The great damage which was frequently wrought to shipping along the coast of Morocco by great ocean swells has been the subject of a number of studies. The author's studies have led him to the conclusion that these destructive swells can be forecast from the pressure distribution in the portion of the Atlantic to the east and northeast of Morocco. The conclusions, based upon the study of the effects of 210 low-pressure areas, are as follows:

I. A swell produced at Casablanca is the consequence of—

1. A depression on the ocean between the Azores and the British Isles, and light northwest winds in the region between the African coast and the depression. If the depression is intense, the swells will be correspondingly greater. These waves originating within the LOW require from 2 to 5 days to reach the coast of Morocco.

2. A depression moving eastward between the Azores and Portugal. In this case the swells are rarely large at Casablanca. They require from 24 to 48 hours to reach the coast.

3. Secondary depressions arising from LOWS in the north, moving southward over western Europe from the region of Norway and the British Isles, and giving rise to depressions over the Mediterranean.

II. A swell is weakened or made ineffective at Casablanca—

1. When there is an anticyclone over the region between the coast of Morocco and the depression.

2. When the depressions pass north of the British Isles.

3. In the case where depressions descend upon Europe when passing between Norway and the British Isles.

4. When an intense LOW with strong winds moves rapidly eastward.

The forecasting of swells can be either made directly at Casablanca by means of comparison of the daily wireless reports from Paris with those of the preceding day, or at Paris; the forecast itself can be forwarded to Casablanca. The author considers that more study should be given the problem, but that it is now possible to avoid such catastrophes as have been experienced along the coast of Morocco.—*C. L. M.*

MEAN SEA LEVEL.

By D'A. W. THOMPSON.

[Abstract reprinted from *Science Abstracts*, Nov. 29, 1919, p. 504. Article in *Nature*, Aug. 21, 1919, pp. 493-495.]

The level of the sea, or more generally, the form of its surface, is the resultant of two kinds of forces after eliminating the effects of the tides. There is the action of the sea currents and densities (intrinsic forces); and that of wind and barometric pressure (extrinsic forces). Witting thus summarizes the effects of the extrinsic forces: (1) Every barometric distribution of any permanency produces a deformation of the surface of the sea. (2) The ascending slope so produced is not identical in direction with the barometric gradient, but deviates to the right in the Northern Hemisphere. (3) The amount of slope is greater than that which would correspond with the hydrostatic pressure, induced by the barometric distribution. With regard to the intrinsic forces we know enough to choose a point at sea where no movements are caused by the distribution of densities. This is the zero pressure level. A geodetic surface drawn through this point may be considered the datum level. Proceeding outward from such a point, Witting has calculated the hydrodynamical gradient due to densities, and added to it the effect of barometric pressures. He has found that levels thus calculated for the Baltic area agree to a surprising closeness with the determinations of precise levels.

The question of secular changes of level is beset with difficulties. But assuming the coast from Wismar to Pillau has kept at constant level, Witting mapped the changes in level in the Baltic from 1898 to 1912. Some minor fluctuations are related to seismic phenomena; e. g., there was an interruption in the general upheaval at the time of the Scandinavian earthquake, 1904. For some centuries past the elevation of the Fennoscandian